**Comment on Wind-Blown Coal Dust from the Proposed Cherry Point Terminal**

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I am a physicist and writer living on Orcas Island, having moved here with my family in the summer of 2010 after owning a vacation home on the island since 2002. One of the primary reasons for this move was because I am an avid kayaker, and the San Juan archipelago is one of this sport's premier destinations. What makes it so popular is the combination of abundant wildlife in, on and around its waters — including eagles, salmon, harbor seals, and orcas — together with its challenging tidal currents and magnificent shorelines. Most kayakers in the islands relate closely to this marine community and care deeply that it continues to thrive. This has been true for me, too, ever since I first launched a kayak on Orcas over a decade ago.

I often kayak around the Outer Islands north of Orcas Island — Sucia, Matia and Patos — which are directly opposite Cherry Point across Georgia Strait, 7–8 miles away. The wildlife community around these uninhabited islands seems to be doing fairly well, especially the harbor seals that I often see breeding on their north shores. But long-time Orcas residents assert that it has declined in recent decades, particularly the annual salmon runs that once drew sport fishermen from far away. Thus I am deeply concerned that activities at, or related to, the proposed Gateway Pacific Terminal at Cherry Point could have significant negative impacts upon the fragile marine community in the San Juan Islands.

Principal among these concerns is the possibility that coal (and its toxins) could escape from the terminal and find its way into Georgia Strait waters. From there it could then make its way physically or biologically to the San Juan Islands — drifting here via the strong currents and winds that characterize the area, or by uptake into the marine food chain, beginning with the forage fish that spawn in the waters off the coast of Whatcom County. Coal contains significant quantities of arsenic, cadmium, lead, mercury and polycyclic aromatic hydrocarbons, which are recognized as carcinogens and/or neurotoxins. If ingested by the forage fish and other marine organisms low in the food chain, they would become concentrated in tissues of the salmon, harbor seals, seabirds and other wildlife that feed upon them.

As a Ph.D. physicist from MIT, I recognize how fine particles of coal dust can easily be wafted by winds far away from intended their destinations in storage piles. I have taught physics courses at Stanford and the University of California, and once edited and published a book about wind power. I have also been involved in three large physics projects — two almost as large as the Gateway project and one much bigger. I have studied large projects and their management, funded by the National Science Foundation and U.S. Department of Energy. So I know what can go seriously awry in such projects, despite the best plans of dedicated engineers and scientists.

The plans for this coal terminal should therefore be scrutinized closely by regulators and compared with what has happened *in actual practice* at other bulk shipping terminals employing similar technologies — under similar weather and marine conditions. Abstract paper designs, engineering calculations, and computer simulations are not by themselves sufficient. Unanticipated events occur that can lead to the release of large amounts of coal dust. The best way to avoid them is to learn from real-world experiences and take measures to prevent recurrences.

**Wind-Blown Coal Dust**

The proposed Cherry Point site is located in one of the windiest regions in northwest Washington. Strong winds blow regularly, frequently out into Georgia Strait. The prevailing winds, which often exceed 20 mph with gusts over 30 mph and reach gale force in the winter, blow from the south and east-northeast (for example, see the wind-rose chart in Fig. 5-24 of the Gateway Terminal project information document[1]). In the latter case, these winds would spread coal dust into the Cherry Point Aquatic Reserve unless adequate preventative measures are taken. Open coal storage piles, projected to reach over 60 feet high, will be difficult if not impossible to shield from these strong winds. And while the coal transferred from these piles to bulk carriers at the pier will pass through covered conveyor belts,[2] deposition of coal onto these piles and its recovery from them will be exposed to whatever winds happen to blow when these transfers occur.

In October 2012, for example, steady winds at Cherry Point (determined at an offshore buoy, station MCHYW1) equaled or exceeded 20 mph on 20 out of 31 days, with gusts that exceeded 30 mph on six of those days (see Appendix 1). On

seven days, the prevailing winds blew from the NE or ENE out into Georgia Strait. In December 2012, the winds were even stronger; steady winds equaled or exceeded 30 mph on eight days, with gusts above 40 mph on six of them.

Measurements made by a nearby land-based station at Sandy Point Shores (KWAFERND4) located about four miles SSE of Cherry Point reveal similar wind patterns (see Appendix 2). In 2011 this station recorded gale-force winds (steady winds exceeding 39 mph) in seven out of twelve months (see Table 1). And in January and February, those gale-force winds came from the NE or NNE, which would have blown terminal coal dust toward Cherry Point Aquatic Reserve less than a mile away. From February 23rd to 25th for example, strong winds blew out of the NE or NNE at speeds exceeding 33 mph each day, gusting up to 52 mph on February 24; the average wind speed during this period was 22 mph. Similar gale-force winds occurred in 2012 from December 15th to 19th (See Appendix 2).

Table 1. Peak and Average Wind Speeds at Sandy Point Shores, 2011

| Month | Steady | Gusts | Bearing | Average |
|---|---|---|---|---|
| January | 40 | 49 | NE | 10.5 |
| February | 43 | 56 | NNE | 13.6 |
| March | 44 | 58 | SSE | 12.8 |
| April | 40 | 50 | SE | 9.9 |
| May | 24 | 29 | SE | 7.1 |
| June | 24 | 29 | S | 7.5 |
| July | 26 | 31 | SW | 6.5 |
| August | 24 | 32 | SSE | 6.4 |
| September | 41 | 48 | SSE | 6.4 |
| October | 28 | 37 | SSE | 7.0 |
| November | 44 | 52 | W | 11.3 |
| December | 50 | 55 | SW | 8.6 |

All speeds are in mph. Bearing is the wind direction when peak winds occurred.

Cherry Point unfortunately sits directly in the path of extremely strong "gap winds" blowing from the NE or ENE, which accelerate through the Fraser River Gap in the Cascade Range. According to noted University of Washington

Professor of Meteorology Clifford Mass and colleagues, who have studied these gap winds in detail, "Strong (> 25 m/s) outflows of arctic air through the Fraser Gap into Western Washington occur approximately once or twice a year."[3] This corresponds to 56 mph, or strong gale-force winds. In fact, Whatcom County and the San Juan Islands experienced hurricane-force Fraser Gap winds exceeding 100 mph in December 1990. According to Mass *et al.*, such winds can be expected to recur every five to ten years[4] — although none have occurred since 1990. They did however arise three times in the 1989–90 period studied and once in 1983.

Under such extremely windy conditions, it is difficult if not impossible to see how coal dust from terminal operations and open storage piles can be fully contained on site. Although the project information document stipulates that earthen berms or wind screens will surround affected areas, and that sprinklers and foggers will be used to wet down the coal dust on conveyor belts and in the piles, these measures will almost certainly be insufficient under such conditions. Unacceptably large quantities of coal dust would be blown into the Cherry Point Aquatic Reserve and beyond into Georgia Strait, perhaps even reaching the San Juan Islands across the Strait. Indeed, the terminal project information document admits that coal dust can be kept within acceptable levels "except for potentially high concentrations of fugitive coal dust *during occasional high-wind events*."[5] Such high-wind conditions unfortunately occur all too frequently at Cherry Point.

Experience from nearby Westshore Terminals in Tsawwassen, BC, and at a coal-shipping facility in Seward, AK, indicate that preventive measures taken to suppress fugitive coal dust have been only partially successful. Wind-blown coal dust losses from the Westshore facility have been estimated at 715 tons per year.[6] During high-wind events, some of this dust has wafted downwind all the way to Point Roberts, about five miles away, blackening houses, cars, patios and small boats.[7] On 12 April 2012, for example, a sudden windstorm blew up shortly after 4 p.m., when a high-pressure system moved in from the west, kicking up a tremendous cloud of coal dust, despite dust-suppression measures supposedly in effect (see Fig. 1). Blowing from the west or west-southwest for about an hour, winds measured at only 28 mph spread tons of coal dust over nearby tidelands and adjacent properties in Delta, BC. In this photo, one can see fine dust particles being carried high aloft by the winds, probably to settle miles away.[8]

Fig. 1. Sudden coal dust storm at Westshore Terminals on the afternoon of 12 April 2012. (photo: Jerry Bierens, for *Delta Optimist*).

Fugitive coal dust from the Seward terminal has been estimated at 500 tons per year (based on the Environmental Protection Agency's AP-42 formulas and factors); this dust usually settles on downwind areas of the town, its harbor, and in Resurrection Bay to the south.[9] The Seward coal experience is particularly germane to the Cherry Point case, for the area undergoes similar gale-force gap winds known as "chinooks" channeled through a mountain gap to the north of the town. These powerful north winds also blow the dust into marine protected areas. The Seward coal terminal can be contrasted with Westshore Terminals, which occupy a man-made peninsula jutting out into Georgia Strait, exposed to winds from all directions. As at the proposed Gateway Pacific Terminal, the Seward storage piles sit well inland, upwind from nearby ocean waters.

Based on the EPA's AP-42 standard formula, and assuming an average wind speed of about 10 mph, one can roughly estimate that the fugitive coal dust emissions from the proposed Gateway Pacific Terminal would be at least 1,000 tons per year.[10] This number does *not* include dust released in high-wind events for which the speed exceeds 20 mph, which cannot be addressed by this formula.

Special techniques (for example, detailed computer simulations of laminar and turbulent air flows through the proposed terminal site) are needed to accurately estimate fugitive dust emissions in such extreme events. The much greater lifting power of these high winds, which increase as the *square* of the wind speed, can transport larger dust particles substantially further than the ordinary 5 to 15 mph winds; these large particles will contain proportionally more coal by weight.[11]

These calculations should also try to account for the local topography and surface features at Cherry Point, for the coal storage piles would sit at the edge of a ravine that will amplify the prevailing southerly winds (See Fig. 4-1 on p. 4-5 of the project information document). Southerly wind speeds will also increase due to compression as the air rises from sea level to the approximate 200-foot level of the planned storage piles and stacker/reclaimers. Accurately estimating fugitive dust emissions in the high-wind events characteristic of Cherry Point is essential in making any credible estimate of total emissions to be expected annually. In the process of estimating such losses, it will be *patently insufficient* to employ only the average wind speeds recorded at the nearby BP Cherry Point refinery, as seems to be suggested by the wind rose in the project information document (p. 5-136).

Separate calculations will be required for the strong winds blowing from the NE and ENE, which would drive fugitive dust toward and into the Cherry Point Aquatic Reserve, which begins less than a mile from the storage piles. And if mitigations such as sprinklers, foggers, earthen berms or wind screens are to be employed, their *actual effectiveness* in extreme Fraser Gap winds must be reliably evaluated by detailed computer simulations, not guessed at. Otherwise, large releases of coal dust will occur during these high winds, as has been repeatedly experienced at the Seward and Westshore terminals. While most of the fugitive coal dust that swirls up in the prevailing southerly winds will probably be blown into the surrounding woods north of the storage piles, there is little to block this dust when kicked up by the inevitable gale-force NE and ENE winds. In 50 mph winds, large plumes of coal dust far worse than what was observed at Westshore on 12 April 2012 will be blown down the bluff and directly into Georgia Strait.

The accumulations of coal on the sea floor that will occur can be reliably estimated by again considering the Westshore example. Around this terminal, sea-floor deposits of coal dust have been measured in detail; coal concentrations

over 10 percent have been observed near the terminal (see Fig. 2), and 2 percent more than a mile away.[12] The deposits accumulated over more than two decades despite concerted efforts to contain fugitive coal-dust emissions at the terminal. While the extreme concentrations near the two docks can be largely attributed to coal losses during the ship-loading process (see my EIS comment #5517, "Coal Losses During the Ship-Loading Process"), they sit atop a broad distribution of deposits that must have arisen due to wind-blown coal dust from other terminal operations. Note especially the coal accumulations observed east and northeast of the terminal, which correlate well with the big dust storm recorded in Fig. 1.

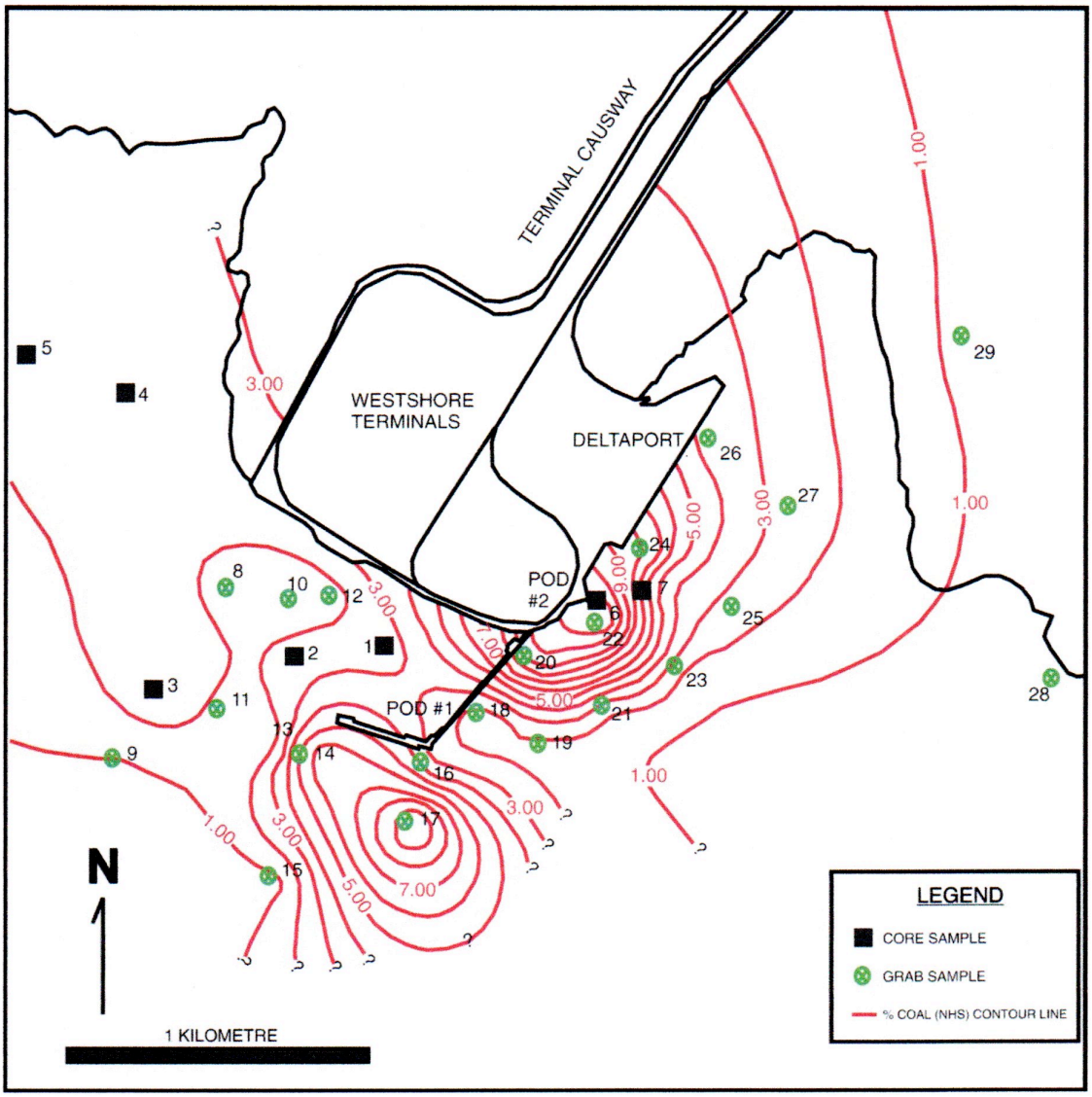


Figure 2. Coal concentrations in surface sediments near Westshore Terminals, Delta, BC. (Source: Johnson and Bustin, "Coal Dust Dispersal Around a Marine Coal Terminal.")

It seems inevitable that coal residues will substantially contaminate the waters of the Cherry Point Aquatic Reserve, the major spawning grounds of the dwindling population of Cherry Point herring.[13] The only questions remaining are how much and how far. Previously over ten times larger, this population has been declining since the 1970s, when Westshore Terminals and other industrial port facilities such as the BP Cherry Point Refinery were established.[14] The draft Environmental Impact Statement should assess whether any causal connection exists here. As tons of fugitive coal dust inevitably accumulate in the Reserve, it will introduce polycyclic aromatic hydrocarbons plus heavy metals such as lead, mercury and cadmium into its eelgrass beds and onto the sea floor. These highly toxic substances would soon enter into the local food chain and herring diet, with adverse effects that could easily result in a complete species die-off. That would adversely impact the threatened Salish Sea populations of Chinook salmon and southern resident orca, for the herring are the basis of a food chain on which both depend, as do harbor seals, seabirds and other marine species. Coal dust can also adversely impact bottom feeders such as sand lance, shellfish and Dungeness crabs, upon which local Lummi fishermen rely for sustenance and livelihood. Lighter dust particles will drift northwest and southeast with prevailing winds and currents to other areas of the Reserve — as well as west into Georgia Strait.

**Studies and Actions Requested**

In summary, the Gateway Pacific Terminal should be designed to limit, if not completely eliminate, fugitive coal dust in the strong gale-force winds that can be expected to occur annually. Otherwise, Fraser Gap winds from the NE and ENE will blow this dust out into the Cherry Point Aquatic Reserve, Georgia Strait, and possibly as far as the San Juan Islands. If the facility is designed only for the average winds, unacceptable releases of fugitive coal dust will inevitably occur during the strongest winds that arise. And before construction can begin, measures designed to control fugitive coal dust should be demonstrated to work successfully *beyond a reasonable doubt*. Terminal planners might have to include certain operational restrictions, such as halting coal transfers when wind speeds exceed that for which fugitive emissions can be easily controlled. (At the Seward facility, for example, no coal can be transferred to carriers when the wind speed

rises above 12 knots, or 14 mph.[15]) A far better alternative would be to eliminate the open storage piles entirely and instead build a totally covered storage facility, which would probably be smaller and have less shipment capacity. Such covered storage facilities indeed exist — for example, at the Amstuv BV Coal Terminal in Amsterdam, the Baltic Coal Terminal in Ventspils, Latvia, and the Hsin-Ta Fossil Power Station in Kaohsiung, Taiwan.[16] If Gateway Pacific Terminal proposers cannot confidently assure Whatcom County planners and the WA Department of Ecology that unacceptable releases of fugitive coal dust will definitely *not* occur from open storage piles, then a covered coal-storage facility is the only possible option remaining, short of abandoning plans to build the terminal.

I therefore respectfully request that you address the following questions in the Environmental Impact Statement for the Gateway Pacific Terminal:

1. What are the actual wind speeds that can reasonably be expected to occur in and around the coal storage piles and transfer operations, including the effects of local topography and surface features? What local winds speeds will occur during the gale-force Fraser Gap winds that arise regularly in this vicinity?
2. What is the likelihood that large quantities of coal dust will be entrained by these winds and blown into the waters of the Cherry Point Aquatic Reserve, necessarily including the effects of turbulent air flow around the piles? Given the high winds at Cherry Point and 48 million tons of coal to be shipped each year, how many tons will find their way into these waters annually?
3. What measures can be taken to reduce or eliminate these fugitive coal-dust losses — for example, by halting operations during high winds? And if these measures are deemed to be insufficient by regulators, can terminal planners instead design a facility with covered coal-storage piles and operations?
4. What will be the likely impacts upon marine life — principally the herring that spawn nearby every spring and Dungeness crabs that feed on the sea floor — of the tons of coal dust that will inevitably accumulate in the Aquatic Reserve and adjacent Georgia Strait waters during the many years the terminal would operate? What are the probable impacts on eelgrass beds, which help filter carbon dioxide out of the seawater, reduce its acidity, and store the carbon?

Thank you for your serious consideration of these questions and impacts, which I and many others consider extremely significant.

Appendix 1: Peak Winds (in mph) at Cherry Point Buoy, October 2012.

| Date | Steady | Gusts | Bearing |
|---|---|---|---|
| 10/1 | 27 | 32 | WNW |
| 10/2 | 30 | 35 | NW |
| 10/3 | 20 | 27 | NE |
| 10/4 | 14 | 15 | WNW |
| 10/5 | 15 | 18 | NW |
| 10/6 | 13 | 15 | WNW |
| 10/7 | 8 | 8 | WNW |
| 10/8 | 9 | 10 | ESE |
| 10/9 | 10 | 14 | SSE |
| 10/10 | 7 | 10 | SE |
| 10/11 | 12 | 13 | SSE |
| 10/12 | 21 | 25 | S |
| 10/13 | 25 | 28 | S |
| 10/14 | 37 | 45 | S |
| 10/15 | 24 | 29 | SW |
| 10/16 | 31 | 37 | WSW |
| 10/17 | 14 | 15 | SSW |
| 10/18 | 21 | 31 | SSE |
| 10/19 | 21 | 27 | S |
| 10/20 | 24 | 29 | WSW |
| 10/21 | 21 | 25 | SSE |
| 10/22 | 21 | 29 | ENE |
| 10/23 | 20 | 25 | ENE |
| 10/24 | 22 | 31 | ENE |
| 10/25 | 16 | 20 | ENE |
| 10/26 | 20 | 26 | ENE |
| 10/27 | 17 | 24 | SSE |
| 10/28 | 20 | 25 | S |
| 10/29 | 22 | 25 | SSW |
| 10/30 | 21 | 28 | ENE |
| 10/31 | 24 | 28 | S |

Appendix 2. High Winds at Sandy Point Shores, October to December 2012.

| Date | Steady | Gusts | Bearing | Average |
|---|---|---|---|---|
| October 14 | 36 | 45 | SSE | 17.9 |
| October 22 | 32 | 39 | NE | 15.1 |
| November 17 | 32 | 39 | SW | 12.8 |
| November 18 | 42 | 46 | SSE | 25.5 |
| November 19 | 36 | 41 | SSE | 15.1 |
| November 30 | 32 | 44 | SSE | 20.7 |
| December 1 | 36 | 43 | SSE | 22.6 |
| December 4 | 34 | 47 | SSE | 15.9 |
| December 5 | 40 | 44 | WSW | 16.9 |
| December 7 | 33 | 44 | NNW | 18.2 |
| December 15 | 39 | 44 | SE | 20.6 |
| December 16 | 31 | 39 | ENE | 18.3 |
| December 17 | 35 | 39 | WSW | 21.0 |
| December 19 | 47 | 53 | SSE | 31.7 |
| December 22 | 37 | 45 | SSE | 23.1 |

All speeds are in mph. Bearing is the wind direction when peak winds occurred. These measurements were made by weather station KWAFERND4 about 4 miles SSE of the proposed terminal site, with its anemometer situated at 36 feet above sea level. The wind measurements in Appendix 1 were made just above sea level by a weather buoy offshore of Cherry Point (BUOYCHYW1 or MCHYW1), about 2 miles from the proposed storage piles and transfer facilities.

**References Cited**

[1] Project Information Document, Gateway Pacific Terminal (Seattle: Pacific International Terminals, Inc., 28 February 2011), p. 5-136. Available online at: *https://secureaccess.wa.gov/ofm/iprmt24/site/alias_1357/22894/review_documents.aspx*

[2] *Ibid*., pp. 4-54, 5-141.

[3] Clifford F. Mass, *et al*., A Windstorm in the Lee of a Gap in a Coastal Mountain Barrier," *Monthly Weather Review* (February 1995), pp. 315-331, quote on p. 316. See also Brian A. Colle and Clifford F. Mass, "Windstorms along the Western Side of the Washington Cascade Mountains," Monthly Weather Review (January 1998), pp. 53–71. For a general overview of Fraser Gap winds, see "The Fraser Gap Wind," available at *http://cliffmass.blogspot.com/2009/01/fraser-gap-wind.html.*

[4] Clifford F. Mass, "A Windstorm," p. 316.

[5] Project Information Document, p. 5-140 [emphasis added].

[6] Eric de Place, "Are Coal Export Terminals Good Neighbors?" *Sightline Daily,* 15 March 2011; he quotes this figure from Douglas L. Cope and Kamal K. Bhattacharya, "Coal Terminals: Fugitive Dust Emissions and Control," report to the Canadian Council of Ministers of the Environment, November 2001.

[7] Erik Olson, "Westshore provides glimpse of Longview's potential future with coal," *The Daily News Online*, 12 February 2011.

[8] "Unexpected wind gust stirs up coal dust at Roberts Bank," *The Delta Optimist*, 13 April 2012; *www.delta-optimist.com/Unexpected+wind+gust+stirs+coal+dust+Roberts+Bank/645530/story.html.* Similar windstorms occurred at Cherry Point and Sandy Point Shores when the front passed through at about 5 p.m. Winds gusted up to 26 mph at the former and 31 mph at the latter.

[9] "Seward Coal Loading Facility," Alaska Center for the Environment web site, available at *http://akcenter.org/climate-energy/coal-development-in-alaska/seward-coal-loading-facility*; Russell Maddox, personal communication, 31 October 2012.

[10] "Emissions Factors & AP 42, Compilations of Air Pollutant Emission Factors," Fifth Edition, Vol. I, Section 13.2.4. Aggregate Handling and Storage Piles, *http://www.epa.gov/ttnchie1/ap42*. This calculation assumes a particle size multiplier k = 1.0 and 48 million tons of coal shipped annually.

[11] J. F. Kok et al., "The Physics of Wind-Blown Sand and Dust," *Reports on Progress in Physics*, Vol. 75 (2012), 106901; the authors extensively quote from R. A. Bagnold, *The Physics of Blown Sand and Desert Dunes* (New York: Methuen, 1941). They note that turbulent air flow plays an important role in dust storms, which are "the result of strong turbulent winds entraining large quantities of dust particles" (p. 77). Therefore turbulent flows must be included in simulations of Cherry Point winds and their impact upon the coal dust storage piles.

[12] Ryan Johnson and R. M. Bustin, "Coal Dust Dispersal Around a Marine Coal Terminal (1977–1999), British Columbia: The Fate of Coal Dust in the Marine Environment," *International Journal of Coal Geology,* Vol. 68, No. 1–2 (August 2006), pp. 57–69; see especially Figs. 2 and 3.

[13] Project Information Document, pp. 5-39 to 5-43; see especially Figure 5.6 on p. 5-41.

[14] R. G. Gustafson *et al.*, "Status review of Cherry Point Herring (*clupea pallalsii*) and updated status review of the Georgia Basin Pacific herring distinct population segment under the Endangered Species Act," U. S. Dept. of Commerce, NOAA Technical Memo NMFS-NWFSC-76 (2006).

[15] Russell Maddox, personal communication, 31 October 2012.

[16] Victor Cavazos, "Coal Storage Domes for Taiwanese Power Company," (4 September 2008), available online at *http://www.powderandbulk.com.*